Critical reading and scientific argumentation

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In scientific writing, all stated facts have to be justified, unless they belong to that kind of general knowledge that can be assumed to be known by readers. There are basically three ways to do it:

1. Giving a **mathematical proof** that some property holds or a **counter-example** that it doesn't hold. These are the strongest justifications.

2. Making **experiments to test** some phenomenon. These can only support some hypothesis, but they don't prove anything absolutely. However, it is possible (although rare) that some test works as a counter-example and invalidates a tested hypothesis or reveals a pathological case where the technique doesn't work.

   Typically the results depend on the context, like data that is tested. A good study uses a representative collection of data sets with different properties and tries to evaluate their effect on results.

3. Referring to **previous research** where somebody has either given a proof or a counter-example for something or to their experiments that support or weaken some hypothesis. Here critical reading is important, since publications may be of low scientific quality and make unjustified statements. It is important to always ask how they justify their statement. One should be especially critical, if they use experimental results as their justification, since these are context-dependent and may not be reproducible with other data. If something has been observed systematically in multiple studies, it gives more strength to the observation. This type of observations can also be used to construct a new hypothesis (for own tests) or to reflect one's own results (whether the results are concordant or contradictory, and a trial to understand why).

   In typical bioinformatics papers, proofs are seldom given, but the authors may give counter-examples or explain deficiencies of (other researchers') methods by examples. Note that the athors may not be

aware of the deficiencies of their own new method and the evaluation may be biased (usually, the intention is to show supremacy of the new method), and thus more critical evaluation is found in papers by others. (It is a sign of a good paper if the limitations of a new method are discussed!)

Remember also that scientific papers do contain errors and inaccuracies, especially when the authors are from a different field (e.g., biologists writing on data modelling or statistics). So, read critically, and try to understand the justifications.